Preliminary estimates of surface emissions of atmospheric CO based on measurements from TES and MOPITT

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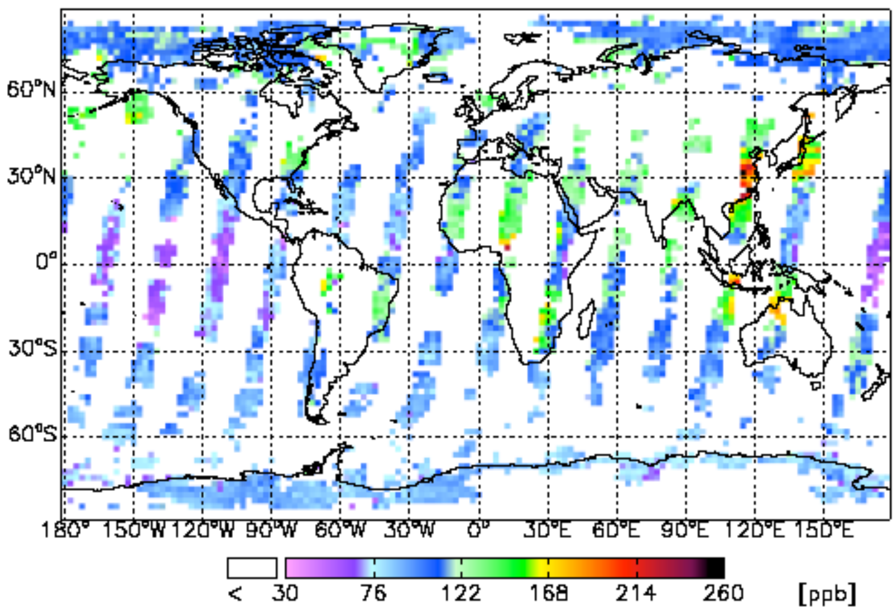
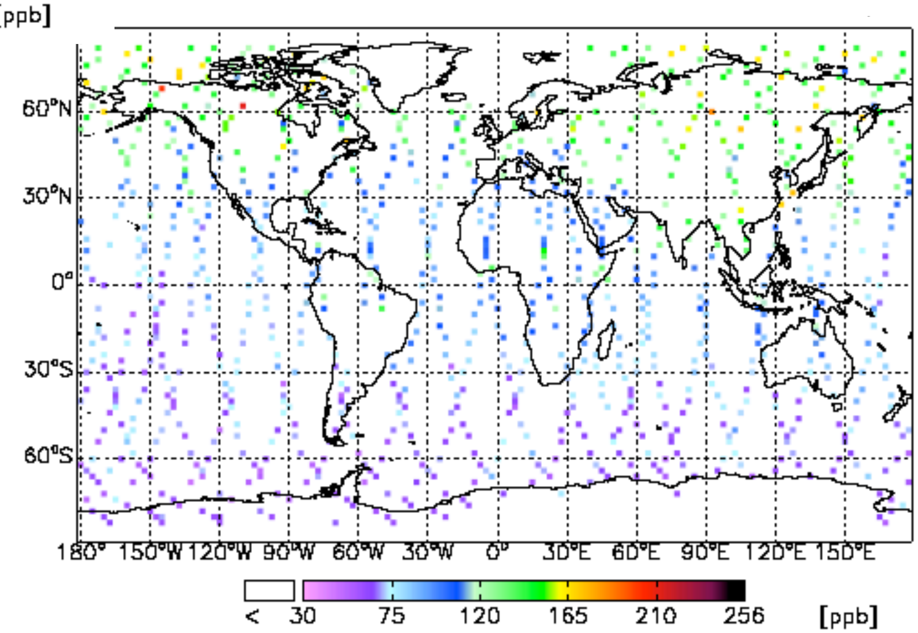
The TES and MOPITT Instruments



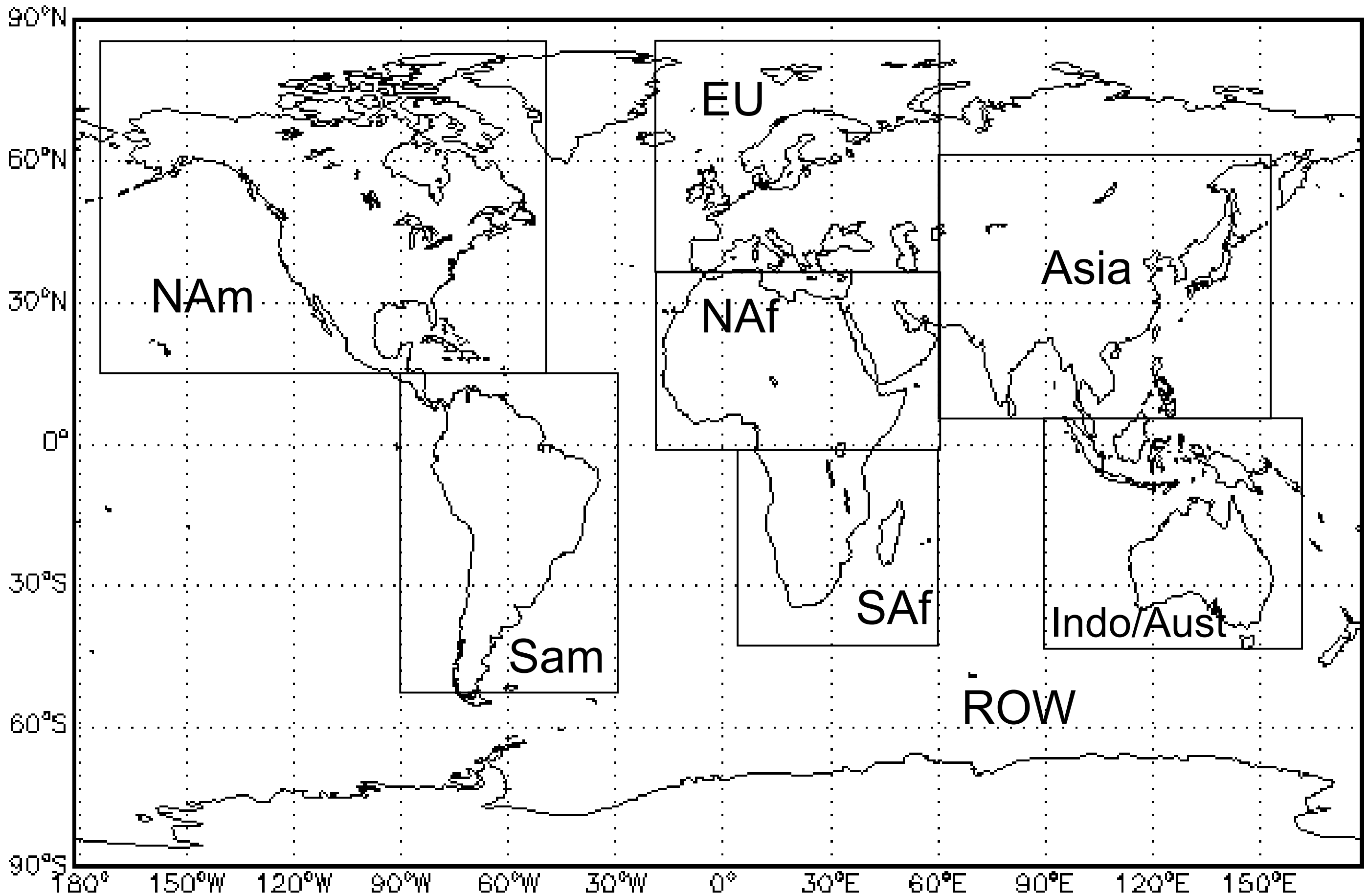
MOPITT: 700 mb, 5 Nov. 2004

TES: Run 2286 750 mb, 4-5 Nov. 2004



What is the consistency between TES, MOPITT, and GEOS-CHEM in the information they provide on the CO sources?

Inversion Analysis State Vector



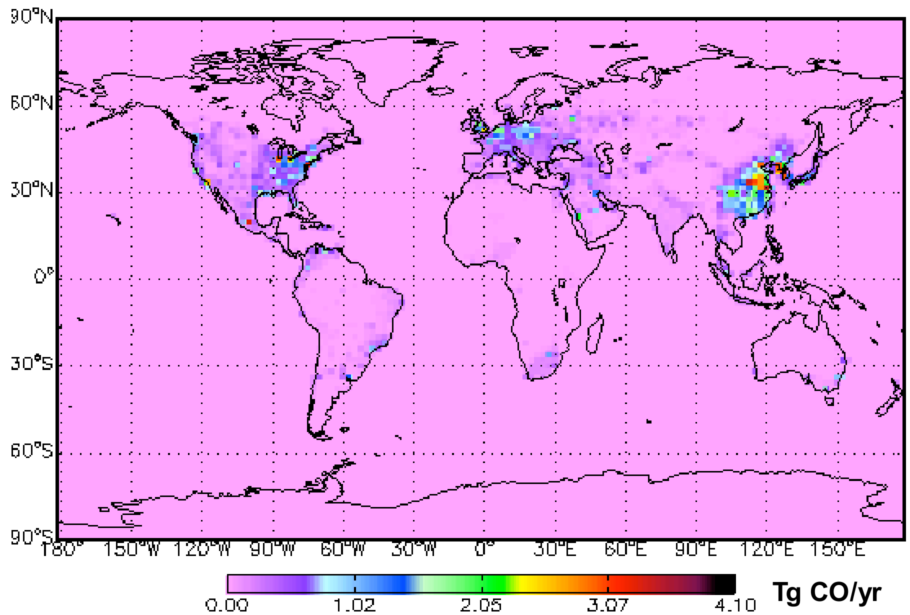
All sources include contributions from oxidation of VOCs

Biomass, biofuel, and fossil fuel emissions are aggregated together

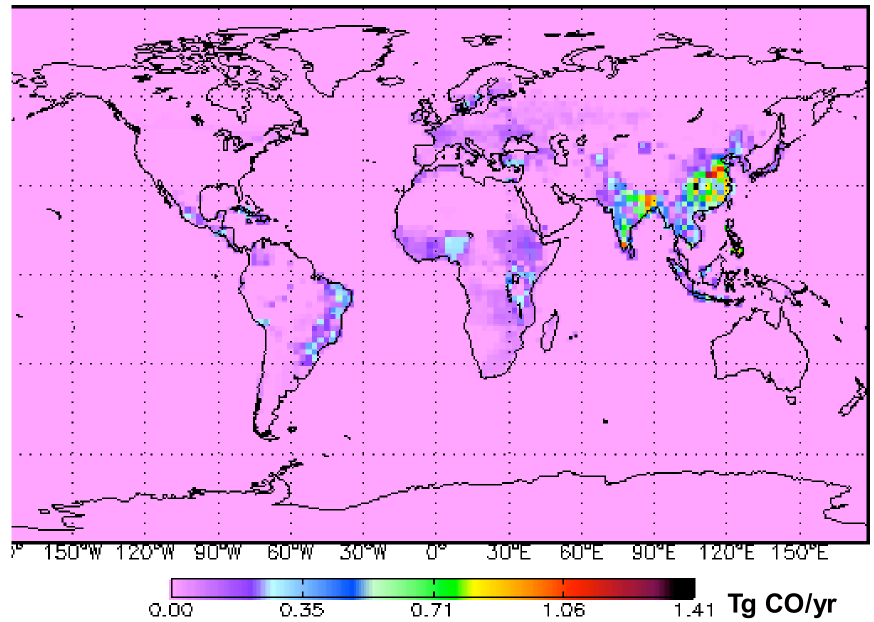
ROW includes methane oxidation and biogenic sources

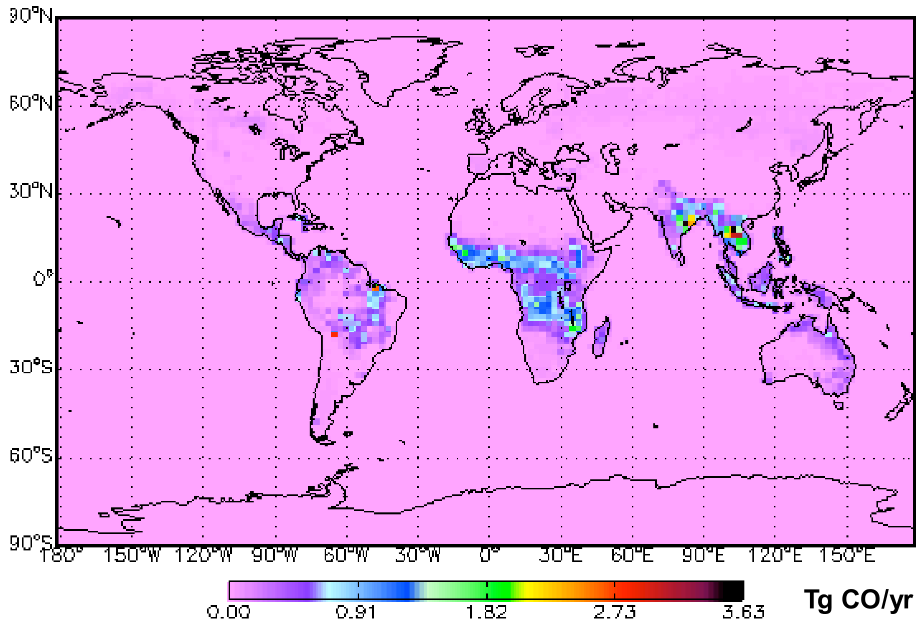
Source Distribution

Fossil Fuels



Biofuels





Biomass Burning

Inversion Methodology

Maximum a posteriori method (assuming Gaussian statistics)

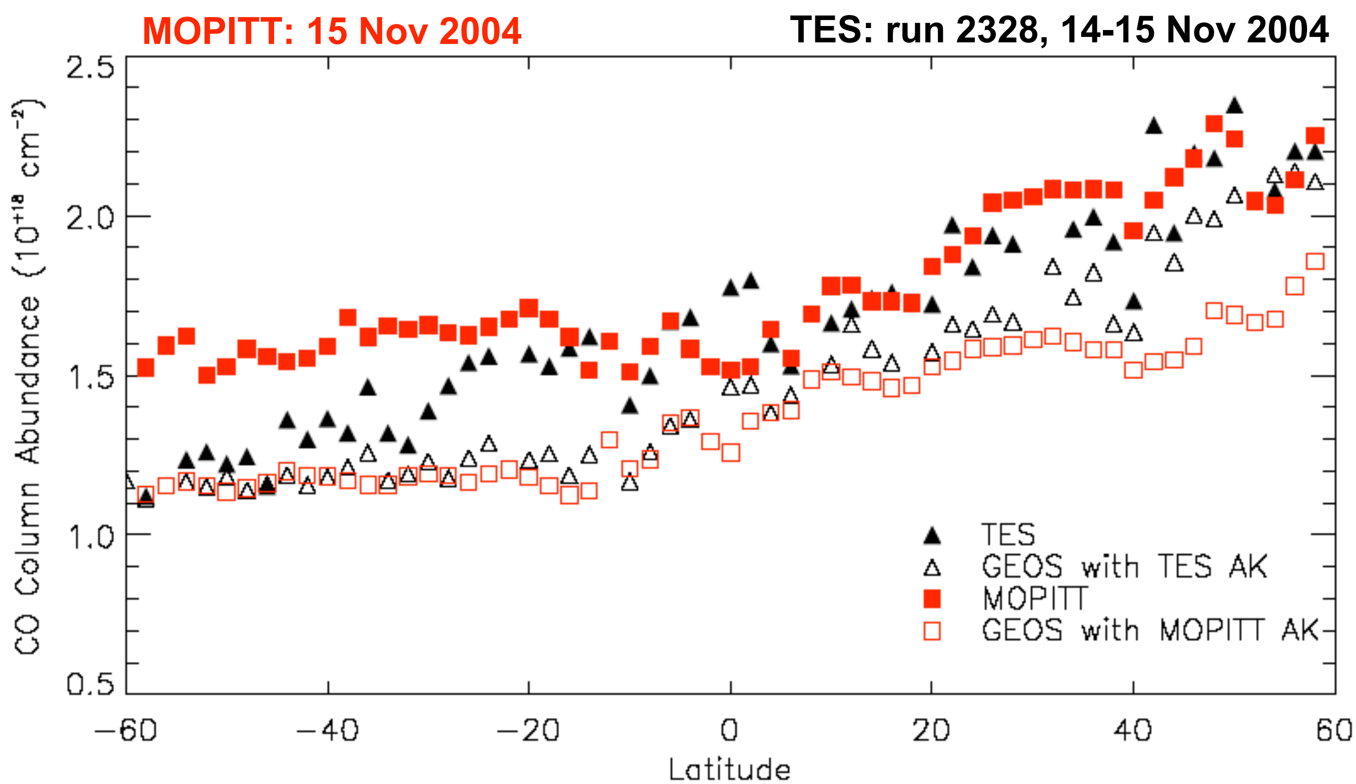
$$J(\mathbf{x}) = [\mathbf{y}^{\mathrm{obs}} - \mathbf{F}(\mathbf{x})]^{\mathrm{T}}\mathbf{S}_y^{-1}[\mathbf{y}^{\mathrm{obs}} - \mathbf{F}(\mathbf{x})] + [\mathbf{x} - \mathbf{x}_a]^{\mathrm{T}}\mathbf{S}_{\mathbf{x}}^{-1}[\mathbf{x} - \mathbf{x}_a]$$

$$\mathbf{F}(\mathbf{x}) = \mathbf{y}_a + \mathbf{A}(\mathbf{H}_{GC}(\mathbf{x}) - \mathbf{y}_a)$$

$$\hat{\mathbf{x}} = \mathbf{x}_a + (\mathbf{K}^{\mathrm{T}}\mathbf{S}_y^{-1}\mathbf{K} + \mathbf{S}_a^{-1})\mathbf{K}^{\mathrm{T}}\mathbf{S}_a^{-1}[\mathbf{y}^{\mathrm{obs}} - \mathbf{F}(\mathbf{x})]$$

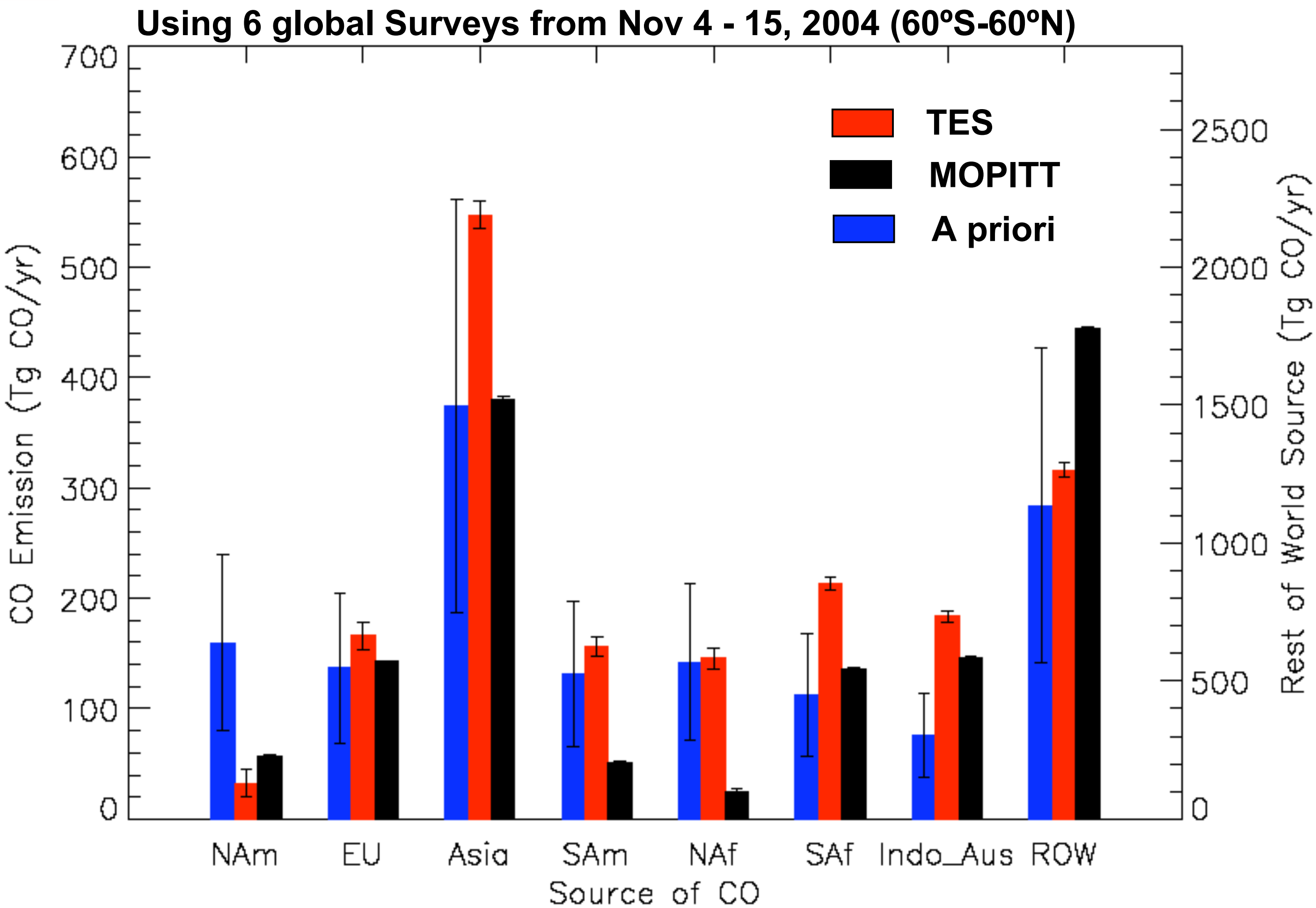
x = the CO sources (state vector)
y^{obs} = observations
F(x) = forward model simulation of x
K = Jacobian (generated by tagging CO from different source regions)
x_a = *a priori* estimate of the CO sources (state vector)
S_x = error covariance of sources
S_y = error covariance of observations
= instrument error + model error + representativeness error
H(x) = GEOS-CHEM model for source state vector x
A = Averaging kernel
y_a = retrieval a priori state vector

Zonal Mean TES and MOPITT CO Columns



- TES and MOPITT are broadly consistent in the southern tropics and northern hemisphere. MOPITT columns are larger in southern hemisphere.
- GEOS-Chem CO columns are significantly less than the MOPITT columns and generally less the TES CO columns
- The largest discrepancy between TES and GEOS-Chem occurs around 20ºS

Inversion Results

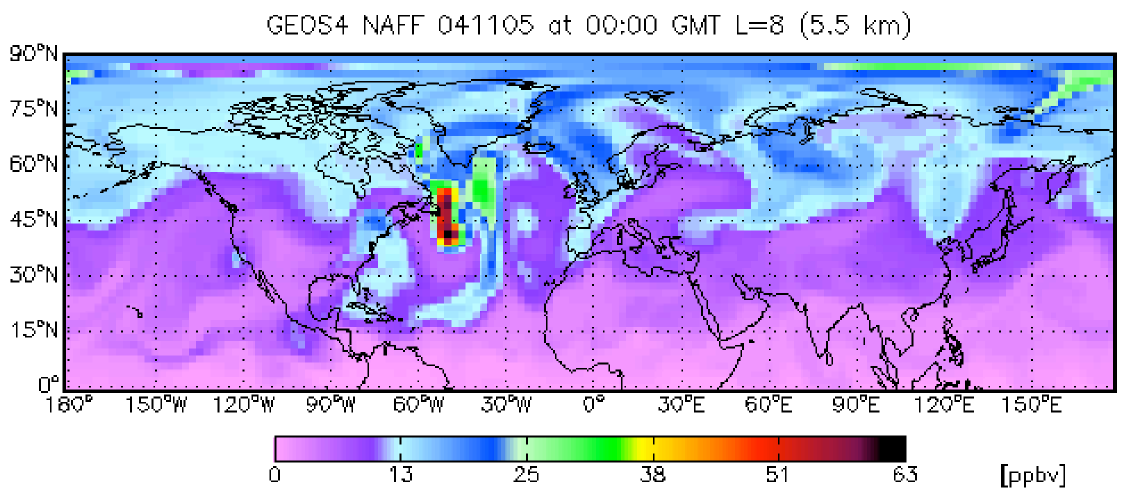


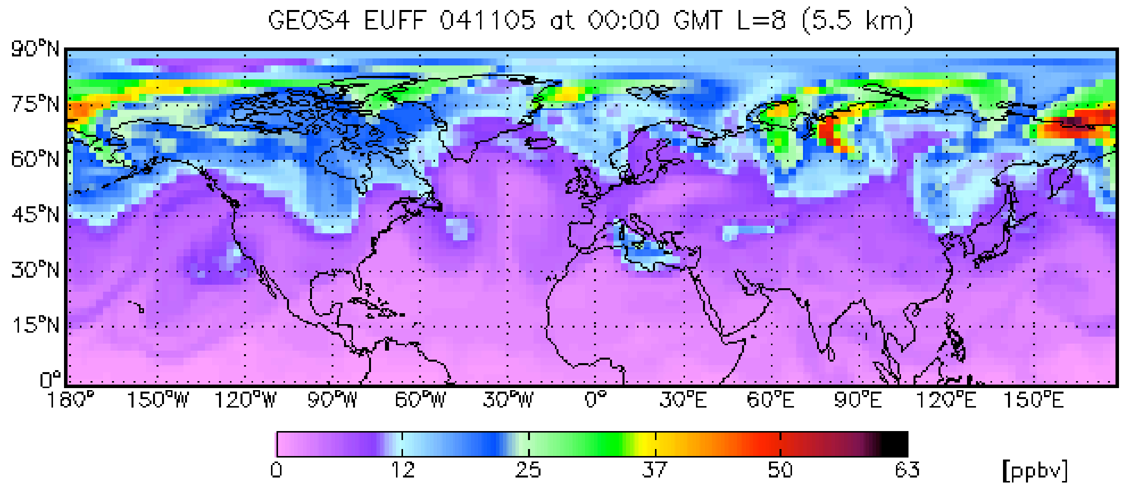
<u>**Global source**</u>
(Tg CO/yr)

A priori: 2270
TES: 2708
MOPITT: 2717

- **Both datasets produce significantly reduced North American emissions**
- **MOPITT results in larger ROW emissions, but reduced South American and north African emissions**
- **TES data suggest significantly higher Asian emissions (at upper end of range of previously published estimates for Asia)**
- **Considerable information about CO Nam/EU sources is available poleward of 60N.**

North American and European CO tracer

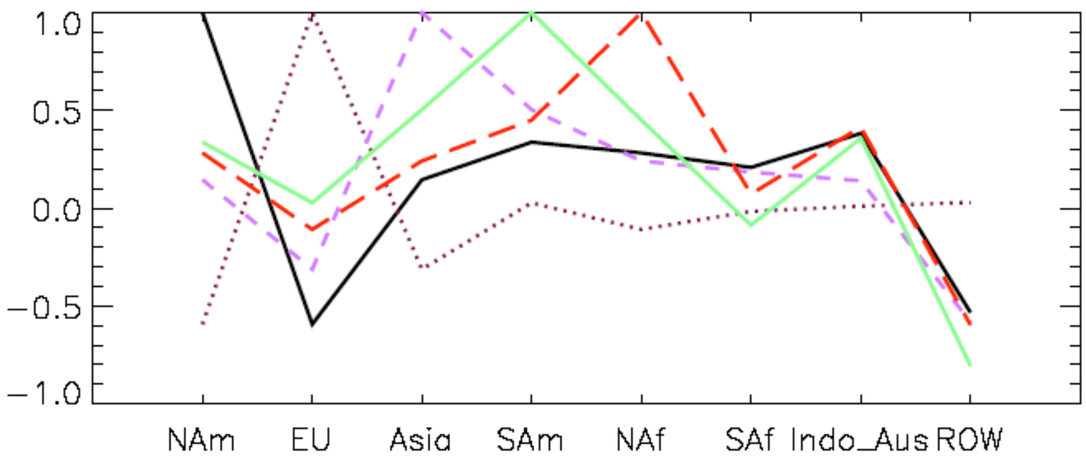




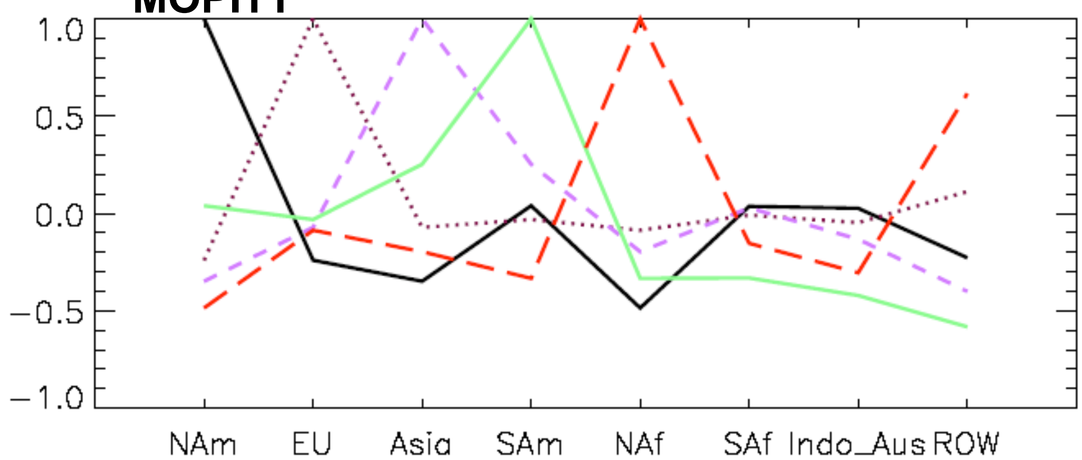
- **Largest CO signal from North America and Europe is poleward of 60ºN**
- **At midlatitudes, in November, North America and Europe provide a small contribution (<15 ppb) to the total CO abundance (>85 ppb)**
- **There is information in the synoptic structures, but we will need more days of observations to exploit it**

A posteriori correlations between Estimates

TES

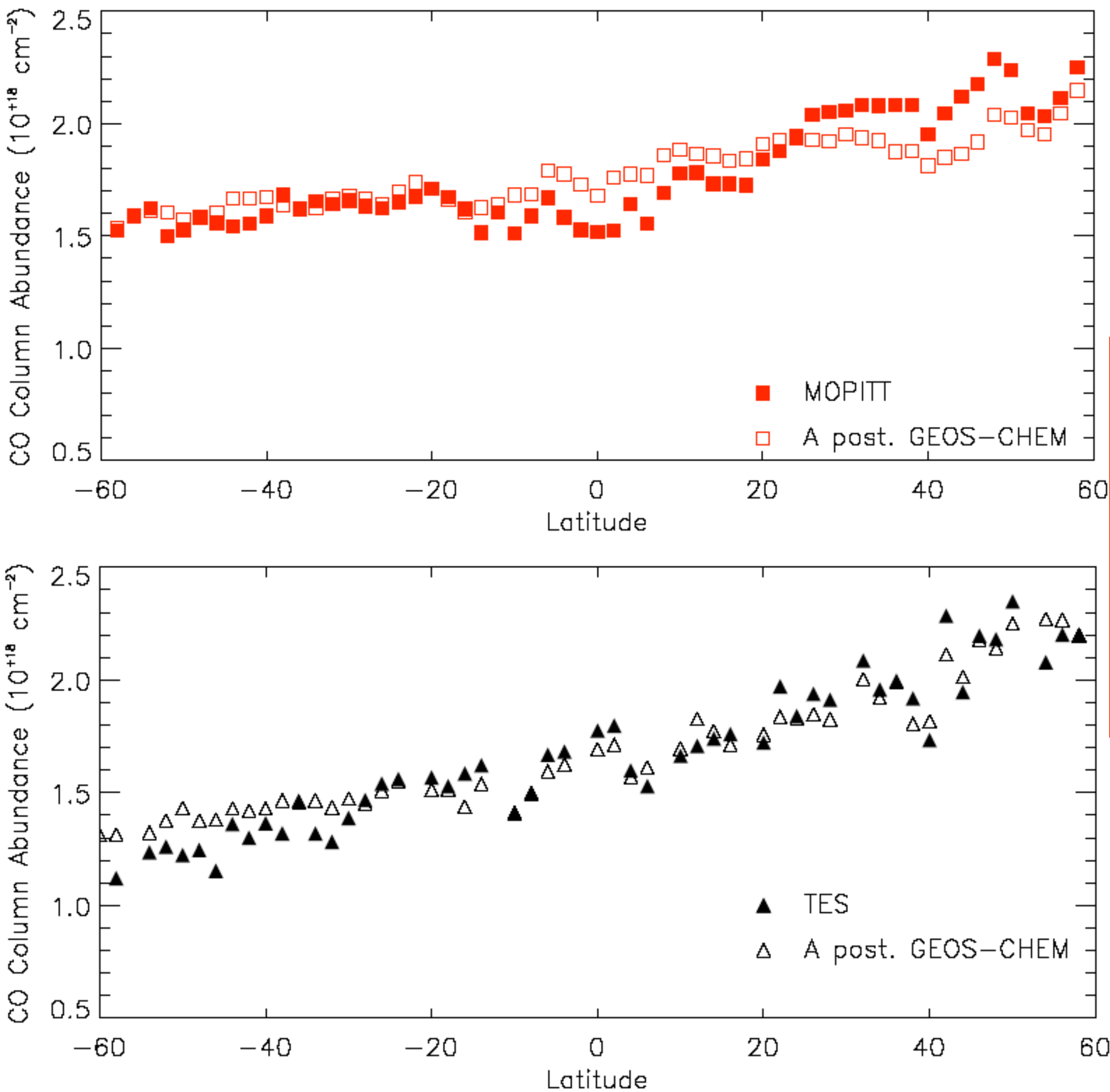


MOPITT



Regional estimates are more strongly correlated with each other and with the background (ROW) with TES, compared to MOPITT

A Posteriori Zonal Mean CO Columns (150ºW - 30ºW)



Both inversions fit the data well, but some source estimates are implausible

⇒ CO-O3 correlations may provide important process-related constraints on the sources

Summary

- TES and MOPITT are broadly consistent in the southern tropics and northern hemisphere.
- Discrepencies exist between GEOS-CHEM and TES/MOPITT, particularly over the southern tropics, suggesting that these observations are providing additional information about source distributions and strengths
- The inversion approach is able to estimate model parameters so that GEOS-CHEM CO fields are in agreement with satellite observations.
- However, additional study is needed to understand systematic errors in the model and satellite observations as well as the impact of prior specification in the estimate:
  - CO abundances from MOPITT are significantly higher in the southern hemisphere and are strongly influencing the global inversion⇒ need to filter MOPITT data for a better comparison with TES
  - Additional effort in constraining ROW is needed due to strong correlations with regional sources
  - There is greater coupling between the source estimates with TES data, compared to MOPITT, probably due to the lower TES data density and the limited number of global surveys used in the analysis
  - More extensive TES time series extended through the winter and spring of the following year should provide a more meaningful comparison of the consistency of these two datasets as well as provide a more accurate estimate of CO source distributions.